

Self-reported Individual and Theoretical Environmental Exposures to the Tobacco
Retail Environment among Adolescent Boys

Abstract

The objective of this study was to examine factors related to self-reported and theoretical exposures to tobacco marketing among Ohio adolescents. Participants were 1,221 adolescent males aged 11 to 16 years residing in one of nine rural Appalachian counties or urban Franklin County in Ohio. The baseline survey used an interviewer-administered item to assess exposure to tobacco marketing in terms of number of convenience store visits in the past week. This measure was later categorized as 0, 1, 2-3 and 4 or more visits in the past week. The survey also measured demographics and tobacco use. ArcGIS software was used to map home, school, and tobacco retail outlet locations and to later count the number of outlets within a boy's path between home and school, which was then categorized as 0, 1, 2-3 and 4 or more possible exposures within a path. Analyses were conducted to determine the associations between personal and neighborhood characteristics and self-reported and theoretical exposures to tobacco marketing. Overall, race and ethnicity, ever having used tobacco, and living in a rural area strongly predicted self-reported exposures to tobacco marketing. However, only living in a rural area significantly increased the likelihood of exposure to theoretical environmental tobacco retail marketing.

Introduction

The smoking of conventional cigarettes causes 90% of all lung cancer deaths, 80% of chronic obstructive pulmonary disease (COPD) deaths, and has been identified as a contributing cause in 20% of all deaths each year in the United States (CDC, 2016). It is important to combat smoking and other tobacco use among adolescents because behavioral patterns established during adolescence can determine risk for future disease (Lawrence, Gootman, & Sim, 2009). In fact, 90% of smokers start smoking by the age of 18 (Surgeon General's Report 2014). Adolescents (ages 10 to 19) and young adults (ages 20 to 24) make up 21% of the population, meaning that these addictive and preventable behaviors also have implications for the healthcare system as a whole (U.S. Census Bureau, 2008). The health-related financial impacts of cigarette smoking alone amount to \$193 billion a year in the U.S. (Kahende, Loomis, Adhikari, & Marshall, 2009).

Current Burden of Tobacco Use Among Adolescents

Tobacco use among adolescents continues to be a major public health issue in the United States. In 2015, about 4.7 million middle and high school students used tobacco (Singh et al., 2016). Although adolescent tobacco use has decreased greatly overall in the past forty years, recent trends have stagnated and for certain novel types of tobacco products, such as electronic cigarettes and cigarillos, use has actually increased (Johnston, O'Malley, Miech, Bachman, & Schulenberg, 2016).

Traditional tobacco products used by adolescents include cigarettes and smokeless tobacco. Cigarette smoking is decreasing. In 2014, 7 percent of adolescents reported smoking in the past month, down from 28 percent in 1997

(Johnston et al., 2016). Smokeless tobacco demonstrates a different type of trend. The use of smokeless tobacco such as snuff or chew is less common among all adolescents (although more common among males than females), but its use among this age cohort increased between 2008 and 2011 (Johnston et al., 2016).

Novel tobacco products used by adolescents include hookahs and electronic cigarettes. Hookahs, or waterpipes, are becoming increasingly popular among adolescents (Johnston et al., 2016). Between 2010 and 2015, the percent of high school seniors who had used hookah in the last year rose from 17 to 20 percent. Electronic cigarette use is also increasing among adolescents (Johnson et al., 2016). Electronic cigarettes, also known as e-cigarettes, are battery-powered devices that can use a variety of flavors to enhance the delivery of aerosolized nicotine (U.S. Food and Drug Administration, 2016). The availability of flavors makes e-cigarettes popular among a young demographic of users. Between 2010 and 2015, the percent of high school seniors who had used an e-cigarette in the past 30 days increased from 1.5 to 16%, and past 30 day use among 8th grade students also more than doubled (Johnston et al., 2016; Singh et al., 2016).

Dual and poly use of tobacco products is also occurring (Johnston et al., 2016), as 25% of 8th and 10th grade students and 50% of 12th grade students who used an e-cigarette in the past 30 days in 2014 had also used conventional cigarettes. Similar studies have shown that little cigars and cigarillos may also promote the initiation and maintenance of other tobacco use among adolescents (Messer, 2015). In fact, 77.3% of middle and high school students who reported using cigars between 1 to 5 times in the past 30 days also reported using at least one

additional tobacco product in the past 30 days in 2014 (CDC, 2014). Like e-cigarettes, these products are popular for their kid-friendly flavors, such as candy, fruit, and chocolate (Lewis et al., 2006).

Tobacco Marketing and Advertising

As one of the world's top advertisers, the tobacco industry has been subject to certain marketing regulations (Saffer & Chaloupka, 2000). Importantly, the Master Settlement Agreement (MSA) of 1998 reached an accord between the United States and the five largest tobacco companies therein (Public Health Law Center, 2015). The MSA imposes restrictions on the direct or indirect targeting of youth through advertising. These restrictions include banning the use of cartoons in marketing and prohibiting the majority of outdoor advertising, including billboard and transit advertising. The MSA also sets guidelines for product placement in the media, restricts the sale of branded merchandise and most sponsorship programs, and bans free product samples except in adult-only facilities. The tobacco industry maintains that its purpose in advertising is only to attract adult consumers, but evidence has repeatedly shown that adolescents are aware of and influenced by such marketing (USDHHS, 1994).

Adolescents are particularly sensitive to the retail environment (Halfon & Hochstein, 2002). In fact, adolescents who report exposures to retail tobacco marketing at rates that are weekly or higher are at an increased risk of experimenting with tobacco (Schooler, Feighery, & Flora, 1996). Furthermore, cigarettes are marketed more at stores where adolescents shop and this marketing

focuses on brands most popular among adolescent smokers (Henriksen, Feighery, Schleicher, Haladjian, & Fortmann, 2004).

Tobacco marketing might target adolescents by addressing such psychological needs as social approval, peer bonding, and autonomy (Wakefield, Flay, Nichter, & Giovini, 2003). Adolescent consumers are told that purchasing a certain product will benefit them by fulfilling that need. Factors like gender can affect how tobacco marketing impacts individuals by altering these needs.

Marketing has been found to influence the uptake of smoking by girls but not boys (Charlton & Blair, 1989). However, other studies report that there are no gender differences in the influence of tobacco marketing on smoking uptake (Pierce et al., 1998).

Since the MSA, research has largely focused on youth-targeted advertising in magazines (Henriksen et al., 2004). However, US cigarette companies spend only millions on magazine advertising versus about \$9 billion on retail marketing, of which around 85% is at the point of sale (King & Siegel, 2001; FTC, 2014). Point of sale (POS) marketing can be defined as any advertising that aims to increase sales at the location at which sales are actually made—for instance, near cash registers and more broadly at a retailer itself (John, Cheney, & Azad, 2009). Point of sale advertising leads adolescents to misperceive the availability and popularity of tobacco, to become interested in its use, and to feel a sense of ease surrounding its purchase (Henriksen, Flora, Feighery, & Fortmann, 2002; Portnoy, Wu, Tworek, Chen, & Borek, 2014; Barnoya, Colditz, Moreland-Russell, Cyr, Snider, & Schootman, 2014). Since POS marketing mainly affects impressionable buyers (Halfon &

Hochstein, 2002), adolescents are at an increased risk of tobacco uptake due to marketing at the POS.

The likelihood of exposure to tobacco marketing at the POS is heavily influenced by the built environment, defined as involving buildings, physical spaces, and products that are formed or changed by people both indoors and outdoors (Bhugra & Minas, 2007). The built environment has been found to affect health through not only the direct negative consequences of chemical and biological agents, but also through impacts resulting from social environments such as housing, transportation, and land use (Papas, Alberg, Ewing, Helzlouer, Gary, & Klassen, 2007). Especially important is the consideration of travel because exposure is directly determined by the paths individuals take (Frank & Engelke, 2001). Land-use also affects exposure by directly affecting proximity between the starting and end point of a trip.

The Neighborhood Environment

From this point forward, the neighborhood will be considered the primary physical entity affecting adolescent health behaviors. It is essential to investigate the neighborhood in terms of homes, activity spaces, and schools, as these are the locations where adolescents spend the majority of their time (Papas et al., 2007).

The neighborhood can be defined by size, socioeconomic status, availability of goods and services, norms, and values (Papas, 2007 et al.; Frick, Klein, Ferketich, & Wewers, 2012). The neighborhood may also be defined by its ability to either enable or disable healthy behaviors through these features. Health-enabling neighborhoods are those that provide environmental resources and interventions

that improve health among occupants of an area, while health-disabling neighborhoods do not provide these resources (Frank & Engelke, 2001).

No matter the chosen definition of neighborhood, its effects are more substantial for the socioeconomically disadvantaged for several key reasons (Papas et al., 2007). Importantly, activity spaces are smaller and a lack of transportation constrains mobility for these individuals, preventing them from accessing health-enabling resources like healthcare or grocery stores. Neighborhood design may also discourage activities such as exercise due to a number of health-disabling factors including poor sidewalks, unsafe roads, and violence.

Urban vs. Rural

Demographics, culture, and economic and political situations shape the neighborhood (Papas et al., 2007; Hartley, 2004). Although similar in nature, these influences may produce markedly different environments and health behaviors between urban and rural areas (Papas et al., 2007). According to Atav and Spencer, 28% of students in rural areas use tobacco compared to 15.4% of urban students, indicating a relationship between adolescent tobacco use and neighborhood location (Atay & Spencer, 2002).

In rural areas, a variety of factors may promote tobacco use among adolescents, including geographic isolation and limited access to healthcare and other resources for tobacco control (Hartley, 2004). Rural culture also produces a fatalistic approach to life, which decreases an individual's willingness to change health-related behaviors.

In Appalachia, 42% of the population is rural and majorly impoverished (Meyer, Toborg, Denhma, & Mande, 2008). In rural Appalachia, tobacco use is higher than in neighboring areas within the same state (Northridge et al., 2008). Moreover, an American Lung Association smoking cessation program targeted at high school students found lower quit rates among Appalachian teenagers compared to urban teenagers (Horn et al., 1999; Horn et al., 2004). Thus, adolescents are smoking at higher rates and quitting at lower rates in rural Appalachian areas.

Adolescents are also exposed to neighborhood features that promote tobacco use in low-income urban communities. Frick and Castro conclude that communities with higher population density and commercial land use (i.e. urban areas) possess a greater density and closer proximity of tobacco retailers to schools (Frick & Castro, 2012). This means that adolescents in these areas are exposed to marketing at these locations more frequently than in other areas. Low-income urban areas also experience a lack of regular access to healthcare and smoking prevention programs (Fiscella & Williams, 2004). Additionally, adolescents of minority racial status and those growing up in distressed neighborhoods—groups more prevalent in urban centers—generally face worse health outcomes than their affluent White peers (Leventhal & Brooks-Gunn, 2004; Lawrence et al., 2009).

School

Researchers have long examined the density and proximity of tobacco retail outlets in relation to schools as an important factor related to adolescent tobacco use (Henriksen, Feighery, Schleicher, Cowling, Kline, & Fortmann, 2008). Findings suggest that the density of tobacco outlets is higher in areas with large populations

of adolescents. In fact, Frick and Castro observed that as tobacco retailer density increased in New York City, the distance between the retailers and schools tended to decrease (Frick & Castro, 2012). A similar trend was found in St. Louis, where tobacco point-of-sale advertising is highly prevalent within 1,000 feet of schools (Barnoya et al., 2014).

Tobacco outlets provide adolescents with opportunities for purchasing cigarettes and increase environmental cues to smoke (Frick & Castro, 2012; Henriksen et al., 2008). Indeed, adolescents are more likely to try smoking if their school is in a neighborhood with a higher concentration of tobacco outlets within walking distance (Henriksen et al., 2008). Adolescents are also likely to prefer brands advertised more heavily at retailers near their schools (Henriksen et al., 2004), which indicates a relationship between tobacco marketing and retailer location.

Tobacco retail location and marketing are also related to school demographics. When the nearest school is a charter or non-public charter school, cigarettes are priced lower than when the nearest school is a private school (Cantrell et al., 2015). This variation may help to explain the greater prevalence of smoking among the socioeconomically disadvantaged, since a greater proportion of minority and low-income students attend public schools nationally. Accordingly, as cigarette prices decrease near schools, the proportion of minority students attending those schools increases.

Home

In addition to schools, residential neighborhoods are important in determining adolescent health behaviors. Regarding the physical neighborhood environment, shorter distances between home and a convenience store are associated with past-month smoking in California (Chuang, Cubbin, Ahn, & Winkleby, 2005) while having a retail outlet within walking distance significantly increased tobacco purchases in New South Wales, Australia, particularly among young men (Paul, Mee, Judd, Walsh, Tang, Penman, & Girgis, 2010). More importantly, the home neighborhood influences adolescent tobacco use through a variety of emotional mechanisms. When adolescents perceive a high level of neighborhood disorder and have a lower sense of hope regarding their circumstances, they are more likely to devalue health and use tobacco (Wilson, Syme, Boyce, Battistich, & Selvin, 2005; Sanders-Phillips, 1996). These perceptions may be impacted by neighborhood factors like socioeconomic status and violence (Furstenburg, 1993; Sanders-Phillips, 1996).

Income Level

The largest contributing factor to the smoking burden in the US is socioeconomic status (SES). Regardless of family socioeconomic level, neighborhood socioeconomic status impacts drug use among adolescents via several mechanisms (Aneshensel & Sucoff, 1996).

Low SES is associated with increased cigarette smoking among adolescents, which may be partly attributed to the neighborhood retail environment (Hanson & Chen, 2007). Low-income neighborhoods possess not only more tobacco advertisements overall but also specifically more storefront POS advertisements

(Laws et al., 2002; Seidenberg, Caughey, Rees, & Connolly, 2010; Frick et al., 2012).

These POS advertisements are bigger, more likely to promote menthol products, advertise lower prices, and are two times as likely to be located within 1,000 feet of a school than those in high-income neighborhoods—all features that appeal to adolescents (Seidenberg et al., 2010).

Also important is the consideration of travel-related exposures in low-income neighborhoods. Pedestrians and cyclists are more sensitive to neighborhood design features than motorists because they move more slowly and thus notice increased differences in environment (Frank & Engelke, 2001). It would therefore be expected that because forms of public mass transit like buses and trains are fast-moving, they would subject individuals to fewer exposures. Low-income individuals forced to walk, cycle, or ride mass transit to their destinations are thus unfairly exposed to tobacco marketing during travel.

Behavioral trends present in low-income neighborhoods also promote adolescent tobacco use. For instance, low SES adults smoke at a greater rate, meaning they not only model smoking behaviors to their children, but also make tobacco accessible in the home, both of which increase adolescent tobacco use (Hanson & Chen, 2007; Resnick et al., 1997). Psychological factors such as stress and depression, which are higher among low SES individuals, can also lead to adolescents using smoking as an outlet (Aneshensel & Sucoff, 1996).

Current Study

While it is known that neighborhood differences between urban and rural areas and income level can affect retail density near schools and homes, little is

known about which adolescents are more likely to experience these exposures on their path between school and home. Since adolescents are especially sensitive to the neighborhood environment it is important to study these exposures and their subsequent impacts on adolescent tobacco use behavior (Mulye, Park, Nelson, Adams, Irwin, & Brindis, 2009). This study examines the real and theoretical daily exposures to tobacco retail marketing that adolescent boys' experience as they travel to and from school in Franklin County, Ohio and 9 rural Appalachian counties. It is hypothesized that adolescents living in low-income urban or rural neighborhoods with longer trips to school and more retailers near their homes or schools will experience increased exposure to tobacco retail marketing.

Methodology

Participants

This study used data from a prospective cohort study which focused on adolescent tobacco initiation in urban and rural areas of Ohio. The participants (N=1,221) consisted of adolescent males aged 11 to 16 residing in any one of the 9 rural Appalachian counties, including Brown, Muskingum, Guernsey, Lawrence, Scioto, Clermont, Morgan, Noble, and Washington, or urban Franklin County in Ohio. The following criteria marked grounds for exclusion: any hearing or vision disability or the inability to read or speak English.

Participants were recruited through one of two methods. First, address-based probability sampling was used. This method involved selecting households from the United States Postal Service's address list and then sending the chosen households a recruitment letter, household roster to complete, and a \$2 bill.

Households with potentially eligible participants received a telephone call from an interviewer, who explained more about the study. Second, non-probability community-based sampling was used. This method employed the following techniques in order to recruit eligible participants: advertising at community events, posting information on different media platforms, providing informative interviews, and giving participants literature to pass on to peers. Regardless of the sampling method, an interviewer set up a meeting time with the parent or legal guardian of the participant, obtained informed consent, and completed the baseline session. The ABS sample and the non-probability sample were merged to create the final analytical dataset. The combined weights were calculated to ensure the representativeness of the target population based on key identified covariates.

Procedures

Before beginning the study, the Institutional Review Board at Ohio State University approved the study protocol. Trained community interviewers obtained informed consent or assent from participants and parents or legal guardians and then conducted the baseline survey. The survey included questions on demographics, tobacco use, other substance use, psychosocial variables, and visits to convenience stores. The non-sensitive survey questions were interviewer-administered, whereas the sensitive ones were administered using an audio-administered computerized survey.

Measures

There were two primary outcome variables of interest: self-reported (real) exposures to POS advertising at convenience stores and environmental (theoretical)

exposures (i.e., our probability estimates of exposures based on home and school locations). The self-reported exposures were measured by the survey question, “How many times have you visited the following stores in the past 7 days: Convenience stores or gas stations (like 7-Eleven, Exxon, Speedway, Duke & Duchess, BP, or Marathon).” Participants were asked to provide a number. Convenience store items were interviewer-administered. The survey measured exposure to tobacco marketing continuously by number of convenience store visits in the past week. This measure was later categorized as 0, 1, 2-3, or 4 or more visits in the past week.

Environmental exposures were estimated using ArcGIS software. Esri geographic information systems software ArcGIS was used to map and analyze theoretical exposures to tobacco retail marketing among adolescent boys. Baseline survey data was used in addition to geospatial data either created from existing baseline data or data from the American Community Survey obtained from United States Census Bureau’s FactFinder website (U.S. Census Bureau, 2015).

First, an Ohio basemap provided by the preloaded data on ArcGIS was used to create the initial map. Geospatial data obtained from the United States Census Bureau was then added to the basemap. This data included shapefiles of the Ohio counties of interest and their respective census tracts.

Home address and school attended were baseline data used to create geospatial point data. A previously obtained list of all tobacco licenses issued within the ten counties of interest was also used to create geospatial point data for tobacco outlets. The addresses for each of these variables were geocoded through Google’s R

script to create coordinates for the features. Then, ArcGIS was used to map the coordinates as point shapefiles for the tobacco outlets, schools, and homes.

The ArcGIS *XY to line* tool was used to create a Euclidian distance line between origin and destination points, being home and school locations, respectively. This line was understood as the theoretical path a boy took between home and school. Then the *Create Buffer* tool was used to create a one-mile buffer around each of these lines. The buffer was understood to capture the variety of different paths a boy could take between home and school. Buffers were not dissolved. The resultant map showed a home point, a school point, a buffer describing the path in between these two points, and retail points within this buffer (Figure 1).

Finally, the *Join by Spatial Location* operation was used to understand which homes belonged in which census tracts and how many retailers existed within particular buffer zones. First, homes were spatially joined to census tracts to understand which homes were in which census tracts. Next, buffers were spatially joined to tobacco retailers in order to understand how many retailer points fell completely within a particular buffer. This count is representative of how many retailers a boy could theoretically pass by between home and school and was later categorized as 0, 1, 2-3, or 4 or more retailers per path in order to easily compare values to self-reported exposures to convenience stores.

Other measures from the baseline survey that were included in the analysis were participant age, race/ethnicity, tobacco use, and neighborhood characteristics like county type. Age was measured continuously and later categorized as 11-13 or

14-16. Race/ethnicity options included: non-Hispanic White, non-Hispanic Black, non-Hispanic other, non-Hispanic multiracial, and Hispanic/Latino. Non-Hispanic other, non-Hispanic multiracial, and Hispanic/Latino were later categorized as “other” because of small cell sizes. Tobacco use was measured by ever-use of any tobacco product (yes or no) and current use was defined as use within the past 30 days (yes or no). County type was defined as either urban (Franklin county) or rural (Brown, Muskingum, Guernsey, Lawrence, Scioto, Clermont, Morgan, Noble, and Washington counties).

Neighborhood poverty was another variable used to characterize neighborhoods. Neighborhood poverty data was obtained from the American Community Survey via the United States Census Bureau’s FactFinder website (U.S. Census Bureau, 2015). Tables containing the percent of families below the poverty line in each Ohio census tract were joined to the census tract shapefiles to understand which homes possessed which neighborhood characteristics. Poverty level for the neighborhood in which the participant resides was measured as either low or high (below vs. at or above poverty level).

Statistical Analysis

All analyses were weighted and accounted for the stratified design. SAS version 9.3 (Cary, NC) was used to analyze the data.

Descriptive statistics were calculated for the entire sample and by region (urban vs. rural). Age, race/ethnicity, and tobacco use status were included as descriptive measures.

Self-reported Exposures

Convenience store visits in the past week was the outcome for this analysis. First, the mean, median and standard deviation of store visits were calculated and reported by participant characteristics, including age (11-13 vs 14-16 years), race/ethnicity (non-Hispanic White, non-Hispanic Black, other), tobacco use status (ever and current), county type (urban vs. rural), and neighborhood poverty (low vs. high). Next, univariate multinomial logistic regression models were run to model the probability of visiting convenience stores 1, 2-3 and 4 or more times vs. 0 times. An adjusted multinomial logistic regression model was also fit that included all of the variables together.

Environmental Exposures

Theoretical exposure to tobacco marketing based on number of tobacco retail outlets within a boy's home to school path was the outcome for this analysis. First, the mean, median and standard deviation of store counts were calculated and reported by participant characteristics, including age (11-13 vs 14-16 years), race/ethnicity (non-Hispanic White, non-Hispanic Black, other), tobacco use status (ever and current), county type (urban vs. rural), and neighborhood poverty (low vs. high). Next, univariate multinomial logistic regression models were run to model the probability of theoretical exposure 1, 2-3 and 4 or more times vs. 0 times. Only one significant odds ratio resulted from the univariate results so an adjusted multinomial logistic regression model that included all of the variables was not fit.

Results

Summary Statistics

This study included 1,221 participants of which 709 (73.5%) were from the urban county and 512 (26.5%) were from one of the nine rural Appalachian counties. ABS was used to recruit 992 participants, whereas the remaining 229 were recruited through community events. The average age of participants was 14.0 years (Table 1). Regarding race/ethnicity, 71.0% identified as non-Hispanic White and 16.7% identified as non-Hispanic Black. These measures are consistent with Census demographic data for the region. As a whole, 16.2% of the sample population had ever used any tobacco product, with a higher proportion of ever-use in the rural sample (23.0%) compared to the urban sample (13.8%). Participants who were home-schooled or could not be reached to confirm their school or home address were excluded from analysis (n=48).

Statistical Findings

Self-Reported Exposures

Means for self-reported and environmental exposures were compared for descriptive purposes. On average, 11-13 year olds visited convenience stores fewer times ($M=1.6$, $SD=0.1$) in the past week compared to 14-16 year olds ($M=2.0$, $SD=0.2$) (Table 2). In our test of convenience store visits in the past week by race/ethnicity, non-Hispanic White boys ($M=1.6$, $SD=0.1$) and “other” race/ethnicity boys ($M=2.1$, $SD=0.4$) visited convenience store fewer times on average than non-Hispanic Black boys ($M=2.8$, $SD=0.3$). Ever-users of tobacco ($M=3.1$, $SD=0.3$) visited convenience stores more times on average in the past week than boys who had never used any tobacco product ($M=1.6$, $SD=0.1$). Similarly, current users of tobacco ($M=3.5$, $SD=0.6$) visited convenience stores more times on average in the past week

than boys not currently using tobacco ($M=1.8$, $SD=0.1$). Boys living in rural ($M=2.1$, $SD=0.1$) areas visited convenience stores more times on average in the past week than boys living in urban areas ($M=1.7$, $SD=0.1$). Boys living in high poverty areas ($M=2.1$, $SD=0.1$) visited convenience stores more times on average in the past week than boys living in low poverty areas ($M=1.6$, $SD=0.1$). These results displayed no significant skewing as shown by the closely related means and medians for this data.

There were significant differences between the numbers of convenience store visits by participant and neighborhood characteristics. For the weighted univariate results (Table 3) from the multinomial logistic regression predicting convenience store visits, there was no difference between 11-13 and 14-16 year olds when we compared 0 to 1 visits and 0 to 2-3 visits in the past week, but older boys had a higher odds of going to the convenience store 4 or more times ($OR=2.09$, $CI=1.28-3.43$) compared younger boys. With respect to race/ethnicity, non-Hispanic Black boys had 2.55-6.19 times the odds of more frequent visits to convenience stores in the past week compared to non-Hispanic White boys. Other racial boys differed significantly from non-Hispanic white boys only when comparing 4 or more visits to 0 times in the past week ($OR=2.03$, $CI=1.01-4.09$). Ever-users of tobacco and rural boys had 2.35-8.16 and 1.71-2.66 times the odds of visiting convenience stores at all levels of frequency, respectively. With respect to neighborhood poverty, boys living in a medium to high poverty area had a higher odds of visiting convenience stores in the past week 2-3 times ($OR=1.80$, $CI=1.20-2.71$) and 4 or more times ($OR=1.91$, $CI=1.16-3.16$) compared to 0 times.

For the weighted multivariable results (Table 4) from the multinomial logistic regression predicting convenience store visits, older boys had a higher odds of visiting convenience stores than younger boys only when comparing 4 or more visits in the past week versus 0 times (OR=1.93, CI=1.14-3.27). Non-Hispanic Black boys were still more likely to visit convenience stores than non-Hispanic White boys at all levels of frequency but these odds increase to 2.80-8.57 times. Other racial boys were also more likely to visit convenience stores than non-Hispanic White boys 4 or more versus 0 times but these odds increase to 3.27 times after adjusting for age, ever-use of tobacco, county type, and neighborhood poverty. Ever-users of tobacco remained significantly more likely to visit convenience stores between the unadjusted and adjusted results for ever-use of tobacco, but these odds decrease to 2.16-5.32 times after adjusting for age, race/ethnicity, county type, and neighborhood poverty. The likelihood of visiting convenience stores remained fairly consistent between the unadjusted and adjusted results for county type, but at the largest frequency this likelihood increases slightly (OR=4.36, CI=2.43-7.85) after adjusting for age, race/ethnicity, and county type. Neighborhood poverty did not significantly relate to convenience store visits after adjustment.

Environmental Exposures

On average, 11-13 year olds had fewer opportunities for exposures to outdoor tobacco advertising (M=20.7, SD=1.5) in their home to school path compared to 14-16 year olds (M=24.4, SD=1.9) (Table 2). In our examination of theoretical exposures to tobacco marketing by race/ethnicity, non-Hispanic White boys (M=15.0, SD=1.1) and other boys (M=24.6, SD=3.1) had fewer opportunities for

exposure on average than non-Hispanic Black boys ($M=52.0$, $SD=4.0$). Ever-users of tobacco ($M=21.4$, $SD=3.0$) and current users of tobacco ($M=18.8$, $SD=3.9$) had fewer potential exposures on average than boys who had never used any tobacco product ($M=22.7$, $SD=1.3$) and boys not currently using tobacco ($M=22.7$, $SD=1.2$). Boys living in urban ($M=27.8$, $SD=1.6$) or medium to high poverty ($M=31.1$, $SD=2.0$) areas had more potential exposures on average in their path than boys living in rural ($M=7.6$, $SD=0.4$) or low poverty areas ($M=14.3$, $SD=1.1$). The medians for these data were not so different from the means that we were led to believe in any significant skewing on the results.

For the weighted univariate results (Table 5) from the multinomial logistic regression predicting theoretical exposures to outdoor tobacco advertising, there were only two significant differences between the numbers of possible exposures by participant or neighborhood characteristic. Non-Hispanic Black boys' neighborhoods were 11.86 times as likely to have 4 or more exposures within a participant's path compared to non-Hispanic White boys' neighborhoods. When we compared theoretical exposure to county type, rural neighborhoods had a lower odds of possessing 4 or more exposures within a home to school path compared to urban neighborhoods ($OR=0.17$, $CI=0.09-0.33$).

Discussion

The most powerful findings in this study are the impact of race/ethnicity, ever-use of tobacco, and county type on predicting visits to convenience stores. Each of these factors significantly increased the odds of a participant visiting a convenience store in the past week at all levels of frequency. Regarding

race/ethnicity, non-Hispanic Black boys were 2.80-8.57 times as likely to visit convenience stores and other boys of racial minority status were 3.27 times as likely at the highest level of frequency (Table 4). Ever-users of tobacco were 2.16 to 5.32 times as likely to convenience stores and rural boys 1.93 to 4.36 times as likely. Age and neighborhood poverty were less important in predicting visits to convenience stores.

Our findings are consistent with previous research indicating that personal characteristics such as race and ethnicity can influence exposure to tobacco marketing (Chuang, Ennett, Bauman, & Foshee, 2005). This exposure is typically higher among non-Hispanic Black populations as found in this study.

It is sensible to assume that ever having used any tobacco product significantly increases convenience store visits in the past week because adolescents may be returning to convenience stores to purchase tobacco products. It is less clear, however, why adolescent boys living in rural counties are more likely to visit convenience stores than their urban counterparts. In this study, a higher percentage of rural boys were current and ever-users of tobacco (Table 1), which could relate to their increased visits to convenience stores, but rural boys had fewer potential exposures on average to tobacco retailers (Table 2). However, previous research also supports a higher use of tobacco among rural adolescents compared to urban adolescents, signifying a connection between adolescent tobacco use and county type (Atay & Spencer, 2002). Factors that may increase adolescent tobacco use in rural areas include geographic isolation, a fatalistic approach to life, social normalization of tobacco use, and higher overall tobacco use among adults, which

may influence adolescent behaviors (Hartley, 2004). Previous research also suggests that there are fewer grocery stores in rural areas—in a study examining the 77 stores in a rural county, 16% were supermarkets, 10% were grocery stores, and an overwhelming 74% were convenience stores (Liese, et. al., 2007). It is possible that although rural boys possess fewer exposures to tobacco retailers on average these retailers are located in more convenient locations for them to purchase necessary items so they visit them more frequently. Since repeat exposures are not recorded in this study, future research should examine this phenomenon more closely to uncover reasons related to the neighborhood why rural adolescents use tobacco more.

This study is among the first to relate adolescents' exposures to tobacco retail marketing to neighborhood factors such as urban or rural neighborhood, poverty level, and the path taken between home and school. Only non-Hispanic Black boys had increased odds (OR=11.86, CI=1.6-87.8) of theoretical exposure to tobacco retail marketing, which is consistent with the literature relating minority racial status to increased exposure to tobacco marketing (Chuang, Ennett, Bauman, & Foshee, 2005). On the other hand, living in a rural county significantly decreased the odds of theoretical exposure to tobacco retail marketing at the highest level of exposure (OR=0.17, CI=0.09-0.33). This finding supports the results that rural boys have on average fewer exposures within their paths (Table 2). However, the results for self-reported exposures to convenience stores show that adolescent boys visit convenience stores more on average (Table 2) and have an increased odds of visiting these stores (Table 4). It again appears that although adolescent boys face

fewer potential exposures to licensed tobacco retailers than their urban counterparts, they are visiting these stores more frequently. Previous research has found that similar exposure is directly linked to the paths individuals take (Frank & Engelke, 2001). This study did not examine the exact path an adolescent takes on their way from home to school, however it is possible that identifying these paths could reveal reasons influencing rural adolescents to visit tobacco retailers more frequently. It is advisable that future research develop a more concrete idea of the impact of neighborhood characteristics such as county type and travel on tobacco marketing exposures among adolescents.

The Master Settlement Agreement (MSA) via several avenues restricts the tobacco industry from directly or indirectly targeting youth through advertising, however adolescents are still aware of and influenced by such tobacco marketing (Public Health Law Center, 2015; USDHHS, 1994). Under Section 906(d) of the Family Smoking Prevention and Tobacco Control Act (FSPTCA) of 2009, the FDA has the ability to set some restrictions on the sale, distribution, and advertising of tobacco products but is greatly limited in its abilities by the First Amendment (FSPTCA, 2009). The FDA could theoretically prohibit tobacco sales and advertising near schools, ban visible displays of tobacco products, set a minimum price on tobacco products, and ban menthol cigarettes, all regulations that would either reduce adolescent exposure to tobacco marketing or make tobacco less attractive to this cohort. However, it is more likely that these goals could be achieved at the state and local levels where under the Federal Cigarette Labeling and Advertising Act (FCLAA) governments are able to regulate the time, place, and manner (although

not content) of tobacco advertising (FCLAA, 1966). Thus, our study's findings could help inform future regulations for restricting adolescent exposure to tobacco advertisements, provided that it clearly targeted adolescent tobacco use and exposures targeted towards them.

Strengths and Limitations

A key strength of this study was its use of a large and diverse sample, which is closely representative of the true male adolescent urban and rural populations in Ohio. This sample was also weighted to population totals for use in analysis, lending generalizability to the results. Another strength of this study was the use of multivariable logistic regression, which strengthened the results for convenience store visits by controlling for the effects of other variables in assessing individual outcomes. Lastly, an important strength of this study was its use of Geographic Information Systems technology to gain new perspectives on the influence of the built neighborhood environment on adolescent exposures to tobacco retail marketing.

One limitation to this study is the fact that the participants verbally reported their convenience store visits to the interviewer, which could have produced a social desirability bias. Additionally, not all tobacco retailers are convenience stores so the two outcomes are not exactly related. Another limitation is that the exact path a boy takes between home and school and his mode of travel are both unknown, meaning that the number of tobacco retailers captured within a boy's path may not actually represent his true exposure. We also recognize that the sample was not entirely random. While it is a diverse sample that has been weighted to population totals,

our parameter estimates may not be generalizable to other populations. Finally, the biggest limitation to this study is that our self-reported and environmental measures of exposure to tobacco retail marketing capture two different outcomes, though related. The self-reported exposure data measures actual convenience store visits, while the environmental exposure data measures the existence of tobacco retailer along a boy's theoretical path from home to school. Thus, these outcomes are not directly comparable.

Conclusions

This study demonstrates that adolescents' personal and neighborhood characteristics impact their likelihood of exposure to the tobacco retail environment. Additionally, evidence reveals that neighborhood factors such as living in an urban or rural neighborhood impacts the theoretical environmental exposures to tobacco retail marketing that adolescents face. The pattern of results suggest that living in a rural area may be of particular concern with respect to reducing the impact of tobacco marketing on adolescents. Longitudinal data used in this study will be particularly useful in helping to determine the long-term impacts of this marketing. Future research with this data will allow us to better solidify the impact of the neighborhood environment on adolescent tobacco use. Current and future results inform federal, state, and local regulations for restricting adolescent exposure to tobacco advertising.

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Tables and Figures

Table 1: Survey Weight Adjusted Distributions of Sociodemographic and Tobacco Use Characteristics of Participants, 2016

Characteristic	Urban (n=709, 73.5%)	Rural (n=512, 26.5%)	Total
Age (Mean \pm SE)	14.0 \pm 0.07	14.0 \pm 0.08	14.0 \pm 0.06
Race/ethnicity			
Non-Hispanic White	63.5%	91.3%	71.0%
Non-Hispanic Black	22.2%	1.6%	16.7%
Non-Hispanic Other	1.9%	0.8%	1.6%
Non-Hispanic Multi-racial	6.3%	5.2%	5.9%
Hispanic/Latino	6.1%	1.1%	4.8%
Any Tobacco			
Ever use	13.8%	23.0%	16.2%
Current use (past 30 days)	3.8%	8.0%	4.9%

Table 2: Weighted Mean and Standard Error, and Unweighted Median, for Self-reported and Theoretical Exposures to Tobacco Advertising at the Point of Sale by Participant and Neighborhood Characteristics

Characteristic	Median, Mean \pm SD for Self-reported Convenience Store Visits	Median, Mean \pm SD for Theoretical Exposures to Convenience Stores
Individual		
Age		
11-13	1, 1.6 \pm 0.1	9, 20.7 \pm 1.5
14-16	2, 2.0 \pm 0.2	8, 24.4 \pm 1.9
Race/ethnicity		
Non-Hispanic White	1, 1.6 \pm 0.1	7, 15.0 \pm 1.1
Non-Hispanic Black	2, 2.8 \pm 0.3	36.5, 52.0 \pm 4.0
Other	2, 2.1 \pm 0.4	12.5, 24.6 \pm 3.1
<i>Any Tobacco</i>		
Ever use		
No	1, 1.6 \pm 0.1	9, 22.7 \pm 1.3
Yes	2, 3.1 \pm 0.3	8, 21.4 \pm 3.0
Current use		
No	1, 1.8 \pm 0.1	9, 22.7 \pm 1.2
Yes	3, 3.5 \pm 0.6	7, 18.8 \pm 3.9
Neighborhood		
County type		
Urban	1, 1.7 \pm 0.1	14, 27.8 \pm 1.6
Rural	2, 2.1 \pm 0.1	4, 7.6 \pm 0.4
Neighborhood Poverty		
Low poverty rate	1, 1.6 \pm 0.1	7, 14.3 \pm 1.1
Medium/high poverty rate	2, 2.1 \pm 0.1	14, 31.1 \pm 2.0

Table 3: Weighted Univariate Results from Multinomial Logistic Regression
Predicting Self-reported Visits to Convenience Stores (OR and 95% Confidence
Intervals)¹

	Visits to Stores		
	0 vs. 1	0 vs. 2-3	0 vs. 4+
Characteristic			
Individual			
Age			
11-13	ref.	ref.	ref.
14-16	0.91 (0.60-1.38)	1.44 (0.97-2.12)	2.09 (1.28-3.43)
Race/ethnicity			
Non-Hispanic White	ref.	ref.	ref.
Non-Hispanic Black	2.55 (1.31-4.94)	3.68 (1.96-6.93)	6.19 (3.02-12.7)
Other	0.98 (0.51-1.88)	1.00 (0.54-1.85)	2.03 (1.01-4.09)
Ever use of Any Tobacco			
No	ref.	ref.	ref.
Yes	2.35 (1.20-4.58)	4.05 (2.20-7.45)	8.16 (4.22-15.8)
Neighborhood			
County Type			
Urban	ref.	ref.	ref.
Rural	1.71 (1.14-2.58)	1.68 (1.17-2.41)	2.66 (1.67-4.25)
Neighborhood Poverty			
Low poverty rate	ref.	ref.	ref.
Medium/high poverty rate	1.28 (0.83-1.97)	1.80 (1.20-2.71)	1.91 (1.16-3.16)

¹**Bold** for a significant result

Table 4: Weighted Multivariable Results from Multinomial Logistic Regression Predicting Self-reported Visits to Convenience Stores (OR and 95% Confidence Intervals)¹

	Visits to Stores		
	0 vs. 1	0 vs. 2-3	0 vs. 4+
Characteristic			
Individual			
Age			
11-13	ref.	ref.	ref.
14-16	0.87 (0.55-1.36)	1.33 (0.87-2.02)	1.93 (1.14-3.27)
Race/ethnicity			
Non-Hispanic White	ref.	ref.	ref.
Non-Hispanic Black	2.80 (1.29-6.07)	3.84 (1.86-7.94)	8.57 (3.74-19.7)
Other	1.04 (0.53-2.06)	1.22 (0.64-2.33)	3.27 (1.49-7.17)
Ever use of Any Tobacco			
No	ref.	ref.	ref.
Yes	2.16 (1.05-4.43)	3.20 (1.69-6.08)	5.32 (2.60-10.9)
Neighborhood			
County Type			
Urban	ref.	ref.	ref.
Rural	1.93 (1.19-3.13)	1.91 (1.23-2.95)	4.36 (2.43-7.85)
Neighborhood Poverty			
Low poverty rate	ref.	ref.	ref.
Medium/high poverty rate	0.92 (0.56-1.51)	1.11 (0.71-1.76)	0.84 (0.48-1.48)

¹**Bold** for a significant result

Table 5: Weighted Univariate Results from Multinomial Logistic Regression
Predicting Theoretical Exposures to Outdoor Tobacco Advertising (OR and 95% Confidence Intervals)¹

	Exposures in Path		
	0 vs. 1	0 vs. 2-3	0 vs. 4+
Characteristic			
Individual			
Age			
11-13	ref.	ref.	ref.
14-16	0.49 (0.21-1.18)	0.64 (0.31-1.34)	0.80 (0.43-1.50)
Race/ethnicity			
Non-Hispanic White	ref.	ref.	ref.
Non-Hispanic Black	3.24 (0.28-37.9)	0.14 (0.01-2.26)	11.86 (1.6-87.8)
Other	1.37 (0.33-5.66)	0.53 (0.13-2.24)	1.98 (0.65-5.98)
Ever use of Any Tobacco			
No	ref.	ref.	ref.
Yes	0.66 (0.21-2.05)	0.93 (0.38-2.34)	0.80 (0.37-1.73)
Neighborhood			
County Type			
Urban	ref.	ref.	ref.
Rural	2.34 (0.84-6.50)	0.94 (0.43-2.02)	0.17 (0.09-0.33)
Neighborhood Poverty			
Low poverty rate	ref.	ref.	ref.
Medium/high poverty rate	0.94 (0.40-2.22)	0.58 (0.28-1.18)	1.12 (0.61-2.05)

¹**Bold** for a significant result

Figure 1: ArcGIS Map Representation of Participant Home and School and Tobacco Retailers within the Home to School Path

